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Evaluation of some new plant type of upland rice (*Oryza sativa* L.) lines derived from cross breeding for the growth and yield characteristics

G R Sadimantara, W Nuraida, N W S Suliartini and Muhidin

Department of Agrotechnology, Faculty of Agriculture, Halu Oleo University Kendari, Southeast Sulawesi, 93232 Indonesia

E-mail: *gusti5@yahoo.com*

Abstract. Improving rice production through cross breeding is one of the efforts to overcome a major challenge in future need of rice consumers. An experiment was conducted to evaluate different upland rice lines for their growth and yield characteristics. Four rice lines including GS44-2 (V1), GS16-2 (V2), GS44-1 (V3), and GS16-1 (V4) were evaluated in a randomized complete block design (RCBD). The variables observed were vegetative character and generative character including grain yield. Data on various growth and yield characteristics revealed there were growth and yield characteristics different among breeding lines of local upland rice. Plant height at age 84 DAP, GS16-2 line was the tallest (92.71 cm) and GS44-1 line the shortest one (70.07 cm). Breeding line of GS16-2 produced higher leaf area (61.0 cm2), panicle length (30.94 cm), grain number per panicle (230.60), and filled grain number (190.25). The lowest unfilled grain percentage (26.67 %) was also recorded from GS16-2 lines. The highest number of tillers, number of productive tillers, grain dry weight, and grain yield were obtained from GS44-2 lines. Further, grain yield component such as grain dry weight and 1000 grain weight recorded positive and significant correlation with number of productive tillers per hill.

1. Introduction

Rice (*Oryza sativa* L.) is second most widely grown cereal crop and the staple food for more than half of world's population, providing two thirds of calorie intake for more than three billion people in Asia, Africa and Latin America [1]. Rice grain contains 75 to 80% starch, 12% water, and 7% protein [2, 3]. Rice is the most important source of staple food in Indonesia, followed by corn and tubers. Rice production in Indonesia is almost entirely dependent on lowland rice, so that the production sustainability is difficult to maintain. This is due to the large conversion of land functions, the degradation of soil fertility, and the disruption of water availability. Therefore, the development of rice cultivation in addition to paddy rice is very necessary especially upland rice [4]. Indonesia is one of the main rice producer but the main primary consumer also [5]. The Indonesian government has two main police to maintain stability of rice supply [6], through the increasing rice production from existing farm while decreasing rice consumption level and promoting local food such as sago [7].

Upland rice in Indonesia generally cultivated in upland areas with low yield (2 ton ha^{-1}), low quality and aged (5-6 months), so that new potential gene sources for the development of high yielding and early maturity varieties necessary to be considered. Other factors that also lead to low production

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of upland rice are the lack of adaptive promising lines, which have good rice quality, medium yield potential, pest and disease resistance, and tolerance to mineral pressure.

The development of high potential yield of upland rice is also aimed to preserve the genetic potential of local upland rice [6] that has undergone genetic erosion, especially the local aromatic and flavor upland rice. In the previous study, obtained the best progeny derived from 33/Wagamba and its reciprocal cross due to several advantages [8] such as performance of upright growth, plant height, number of tillers, and dark green leaves. Furthermore, reported eight promising progeny of upland rice that are tolerant to drought and high potential yield [9]. Genetic diversity information is needed to obtain new varieties that are expected. In order to achieve the objective of selection, it must be known between the agronomic characters, the yield and yield components, so that the selection of one or more characters can be done [10]. The objectives of this study were to evaluate different new plant type of upland rice lines for their growth and yield characteristics.

2. Materials and Methods

Four new plant types of upland rice lines including GS44-2 (V1), GS16-2 (V2), GS44-1 (V3), GS16-1 (V4) were grown at the experiment station of Faculty of Agriculture, Halu Oleo University in a randomized complete block design (RCBD) with four replications. The variables observed were plant height, leaf area, number of tillers, number of productive tillers, flag leaf width, panicle length, number of grains per panicle, number of filled grain per panicle, percentage of unfilled grain, 1000 grain weight, grain dry weight , yield (ton ha^{-1}), and plant biomass. The variances of the data were analyzed by analysis of variance (ANOVA) with SPSS software 13.0 the means were compared using Duncan's Multiple Range Test (DMRT) at the 5% level. The correlation of yield components and yield was analysed using Pearson's correlation coefficient analysis.

3. Results and Discussion

The average of plant growth characteristics of upland rice lines, *i.e.* plant height, panicle length, leaf area, number of tillers, and flag leaf width were varied and significantly different among four new type upland rice lines (table 1). The same result with yield components, *i.e.* number of productive tiller, number of grain per panicle, filled grain per panicle, percentage of unfilled grain, 1.000 grain weight, and grain dry weight (table 2).

3.1. Plant Height

Plant height showed significantly difference among the new plant type upland rice lines (table 1 and figure1). The tallest plant was GS16-2 (92.71 cm) and the shortest was GS44-1 line with 70.01 cm height. According to IRRI [11], plant height is divided into three categories, namely short (<110 cm), medium (110-130 cm), and tall (>130 cm).

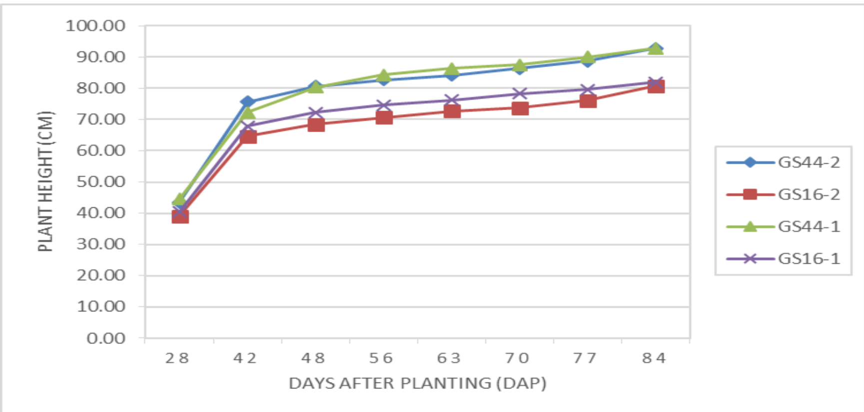

Figure 1. Growth of plant height of four new type upland rice lines

Based on these categories, four upland rice lines evaluated in the present study were short (70.01 cm-92.71 cm). Tall plant is not desired because it is sensitive to lodging, and lodging will reduce grain yield [12]. Furthermore, Bhadru *et al* [13] stated that the plant height is highly correlated with the level of lodging and ease of harvest, so it is one of the important characters in influencing the levels of farmer's acceptance on new cultivar

3.2. Leaf Area

Leaf area measured at 84 day after planting and recorded different among upland rice lines. The lines with the highest leaf area was GS16-2 (61.00 cm^2), significantly different with GS44-2 and GS44-1 lines but was not significantly different with GS16-1 line. The narrowest was GS44-1 line (36.32 cm^2).

3.3. Number of Tillers

The tested lines have average tillers number significant difference each other. GS44-2 was the line with the highest tillers number and significantly different with GS16-1 and GS16-2 lines. The lines with the lowest number of tiller was GS16-2. Wang *et al.* [14] reported that the unequal distribution of photo-synthetically active radiation (PAR) was the source of heterogenity in individual tiller yields, in that early emerging superior tillers pre-empted the uppermost light source, and shaded the late emerging tillers under limited light conditions.

Table 1. Average of plant growth characteristic of upland rice lines

Rice lines	Plant height	Leaf area	Number of tillers	Flag leaf width	Panicle length
GS44-2	80.73 b	45.39 b	25.20 a	1.33 b	29.62 b
GS16-2	92.71 a	61.00 a	12.60 b	1.62 a	30.94 a
GS44-1	70.01 c	36.32 c	24.95 a	1.20 c	28.07 c
GS16-1	89.44 a	57.53 a	14.45 b	1.53 a	28.08 c

Means followed by the same letter are not significantly different at 5 % level by DMRT

3.4. Flag Leaf Width

Flag leaf width at maturity obtained significant difference among upland rice lines which ranging from 1.20-1.62 cm. The lines with the widest flag leaf was GS16-2, while the narrowest was GS44-1 line. The GS16-2 line was significantly different with GS44-2 and GS44-1 lines, respectively.

3.5. Panicle Length

The tested lines have panicle length ranging from 28.07 to 30.94 cm. The lines with the longest panicle was GS16-2; while the shortest was GS44-1 line. Rice plants with long panicles potentially have high number of grain total and high yield because there is a positive correlation between panicle lengths with the number of grains per panicle [15] and weight of 1,000 grain [16].

3.6. Number of Productive Tillers

Number of productive tillers varied significantly among upland rice lines (table 2). The average numbers of productive tillers ranging from 10.45-18.90 tillers with average of 14.33 tillers.

Table 2. Average of yield components of upland rice lines

Rice lines	Productive tillers	Number of grain/ panicle	Number of filled grain	Percentage of unfilled grain	Weight of 1000 grain	Grain dry weight
GS44-2	18.90 a	182.30 bc	149.80 bc	21.70 bc	28.63 b	61.77 a
GS16-2	10.45 b	230.60 a	190.25 a	21.21 cd	26.67 d	45.74 c
GS44-1	16.35 a	167.75 c	138.60 c	21.03 d	30.80 a	55.57 b
GS16-1	11.65 b	200.80 b	162.90 b	23.26 a	27.20 c	41.19 d

Means followed by the same letter are not significantly different at 5 % level by DMRT

The highest number of productive tiller was GS44-2 line, while GS16-2 line recorded the lowest number among lines. Low number of tiller follows the low productivity [17].

3.7. Number of grains per panicle
Range of total grain per panicle was from 167.75 (GS44-1) to 230.60 grains (GS16-2). Average numbers of total grain were more than 195 grains per panicle. The GS16-2 line was significantly different from the GS16-1 line, GS44-2 line, and GS44-1 line. Haryanto *et al* [15] reported that in addition to the number of tillers, panicle length and 1.000 grain weight, the high number of grains total per panicle would also increase rice yield.

3.8. Number of filled grain per panicle
Numbers of filled grains per panicle range from 138.60 to 190.25 grains. GS16-2 had the highest filled grains that was significantly different with GS16-1, GS44-1, and GS44-2 lines. The lowest was GS44-1 with the number of grains of 138.60 grains. In addition to panicle length, the number of grains per panicle is one of yield components that affect the productivity of rice [17]. The difference between the number of grains per panicle and the amount of unfilled grain per panicle is thought to be caused by the genetic influence of each different line. But apart from genetic influences, environmental factors also affect the number of grains per panicle and the amount of unfilled grain per panicle.

3.9. Percentage of unfilled grain
The percentage of unfilled grain ranged from 21.03% to 23.26% and different among the lines. The highest and the lowest percentage of unfilled grain were GS44-1 and GS16-2 lines, respectively. The grain yield is determined by the number of panicles per unit area, the number of grains per panicle, the fertility of the grains and the weight of the grain. Each growth stage contributes to the rice yield.

3.10. Weight of 1000 grain
Weight of 1.000 grain ranged from 26.67 g to 30.80 g. The highest weight was recorded in line GS44-1 (30.80 g) followed by GS44-2 (28.63 g), GS16-1 (27.20) and GS16-2 (26.67 g). The GS44-1 line was found significantly different from the GS44-2, GS16-1, and GS16-2 lines.

3.11. Grain dry weight
Grain dry weight showed significant difference among the upland rice lines tested. Average of grain dry weight of GS44-2 line was the highest compared with GS44-1, GS16-2, and GS16-1 lines. The lowest weight of dried grains recorded on GS16-1 line.

3.12. Grain Yield (t/ha)
Average of grain yield was 5.11 t/ha, while it ranged from 4.12 t/ha to 6.18 t/ha and all of the lines significantly different each other. The highest grain yield (6.18 t/ha) was observed in GS44-2, while the lowest grain yield (4.12 t/ha) was observed in GS16-1 (Fig. 2). Factors that affect the rice yield are not only genetic, but environmental factors also affect the yield of rice plants.

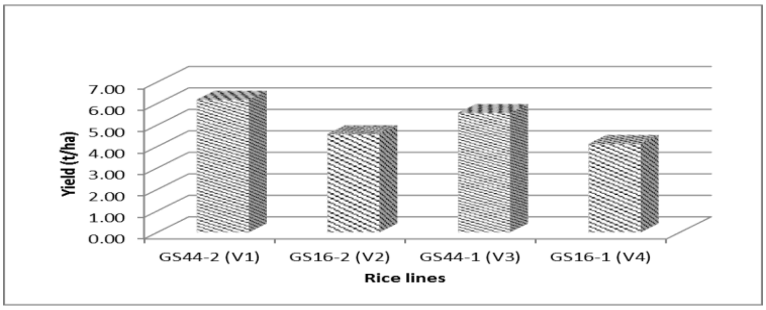

Figure 2. Average yield (t/ha) of four new type upland rice lines

3.13. Characters Correlation

Correlations are measures of the intensity of association between characters. Correlation between characters can be used to determine correlated responses in selection activities. By using correlation analysis, it can be seen whether the agronomic characters and yield component have a positive correlation or negative correlation to the yield of four upland rice lines. As well as on the number of productive tillers and the grain dry weight which has a correlation value of 0.817 (Table 3).

Table 3. Pearson correlation analysis of yield components and yield

	PH	LA	TN	PTN	FLW	PL	GDW	GN	FGN	PUG	TGW
PH	1										
LA	0.947**	1									
TN	-0.840**	-0.806**	1								
PTN	-0.664**	-0.608**	0.781**	1							
FLW	0.95**	0.912**	-0.872**	-0.717**	1						
PL	0.539*	0.444*	-0.412	-0.231	0.5*	1					
DGW	-0.636**	-0.677**	0.835**	0.817**	-0.695**	0.029	1				
GN	0.851**	0.765**	-0.809**	-0.664**	0.792**	0.675**	-0.564*	1			
FGN	0.807**	0.713**	-0.763**	-0.622**	0.739**	0.676**	-0.509*	0.994**	1		
PUG	0.916**	0.889**	-0.892**	-0.754**	0.913**	0.545*	-0.737**	0.846**	0.784**	1	
TGW	-0.925**	-0.873**	0.793**	0.622**	-0.885**	-0.519*	0.662**	-0.777**	-0.719**	-0.926**	1

*PH=plant height, LA=leaf area, TN=tillers number, PTN=productive tillers number, FLW=flag leaf width, PL=panicle length, GDW=grain dry weight, GN=grain number/panicle, FGN=filled grain number, PUG=percentage unfilled grains, TGW=1000-grain weight. *= significant different; **=highly significant different.*

The more number of productive tillers the more dried grain will be produced. Whereas if there are two properties indicating the negative correlation that means a large increase or increase in number of properties will be followed by a decrease in the size or number of other properties. Furthermore, the yield component is a quantitative trait that affects the grain yield, so the high yield is highly depends on the yield components [18]. The correlation coefficient can be either expressed as the total effect of a yield component on the grain yield, directly or indirectly generated by genetic factors, environmental factors, and interactions between the two. Each character that is correlated with the grain yield is broken down into two components: direct and indirect influences. Grain yield was positively associated and not significantly with days to maturity [19].

4. Conclusions

The new plant type of upland rice lines derived from crosses have different growth and yield characteristics. Plant height at age 84 DAP, GS16-2 line was the tallest (92.71 cm) and GS44-1 line the shortest one (70.07 cm). Breeding line of GS16-2 produced higher leaf area (61.0 cm^2), panicle length (30.94 cm), grain number per panicle (230.60), and filled grain number (190.25). The lowest unfilled grain percentage (26.67 %) was also recorded from GS16-2 lines. The highest number of tillers, number of productive tillers, grain dry weight, and grain yield were obtained from GS44-2 lines. Further, grain yield component such as grain dry weight and 1000 grain weight recorded positive and significant correlation with number of productive tillers per hill.

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